

Introduction to Ethanol and Biodiesel

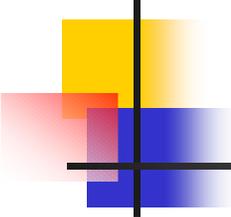
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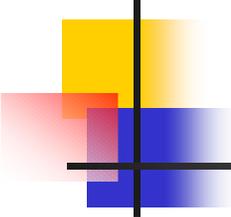
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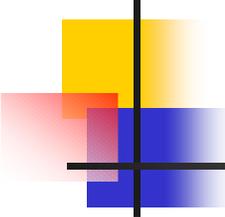
What is Ethanol?

- Another term for ethyl alcohol
- Hydrous ethanol contains at least 5 volume percent water - used for fuel in Brazil
- Anhydrous ethanol contains less than 1 percent water - used for fuel in the U.S.
- Fuel ethanol must be denatured – rendered undrinkable – by the addition of at least 2 volume percent and at most 5 volume percent gasoline.

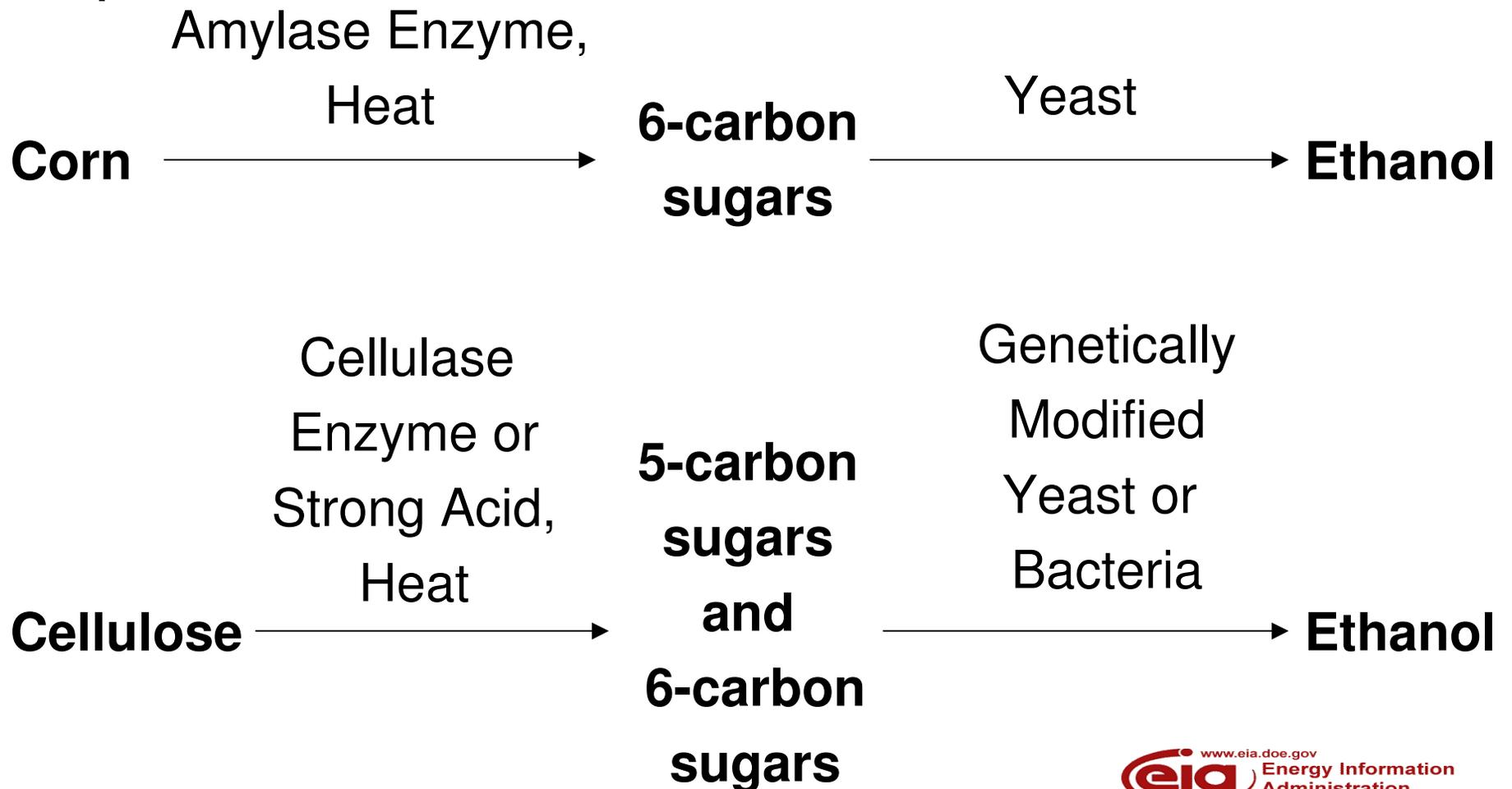


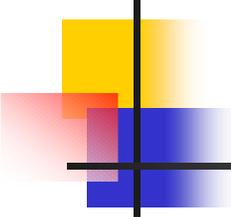
“Kinds of Ethanol”

- Grain ethanol, from corn, sorghum, barley, wheat
- Sugar ethanol, from cane sugar or beets
- Cellulose ethanol, from plant fiber
- Synthetic ethanol, from ethylene in a petroleum refinery or petrochemical plant
- All the same product but made from different raw material
- Synthetic ethanol is not used for fuel in the U.S., because it does not get tax credits that are available for ethanol from biological sources



The Chemistry of Ethanol Production

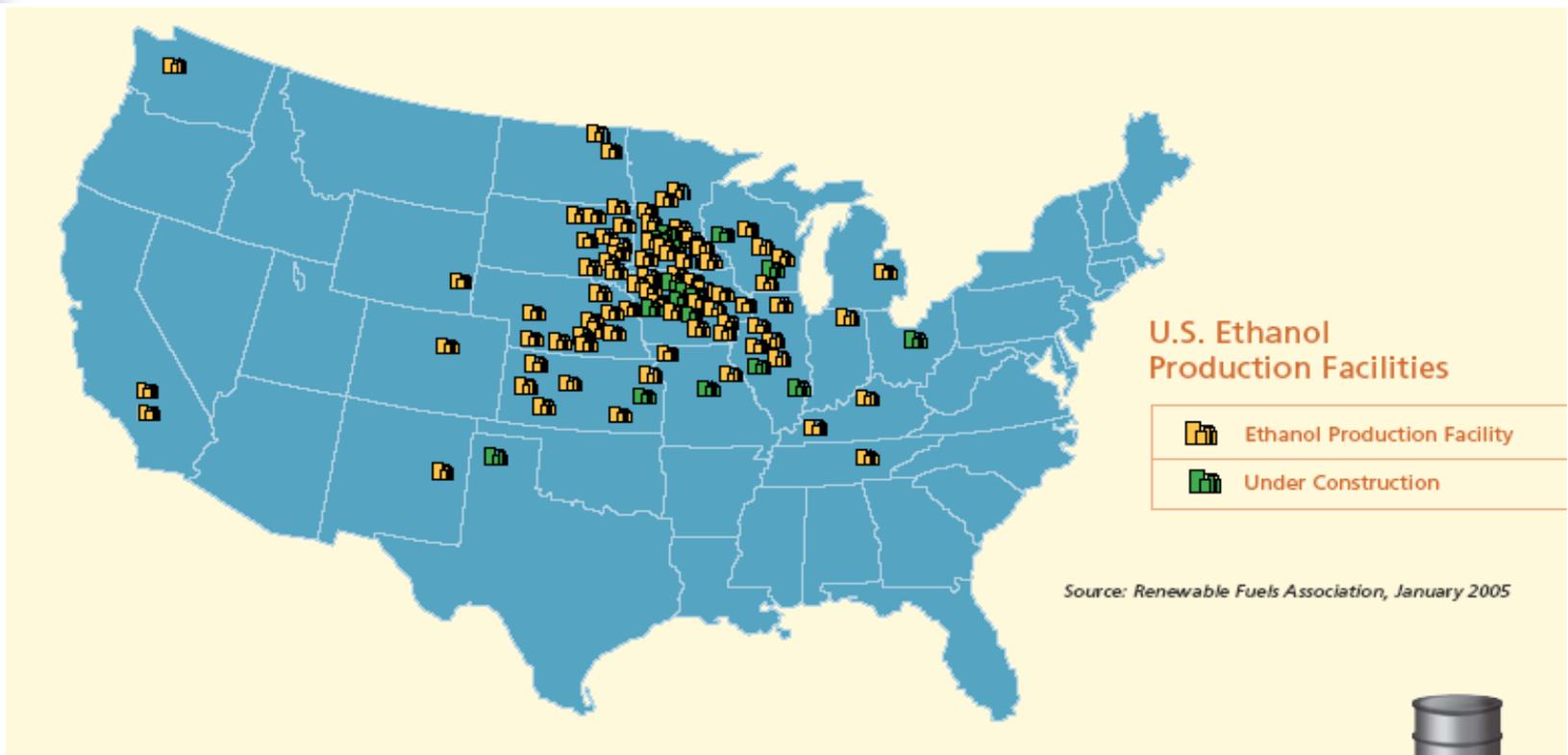


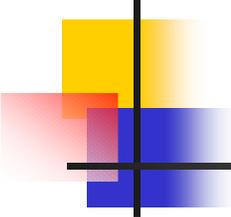


Ethanol Plant Types and Coproducts

- Corn wet mill
 - corn oil
 - corn gluten feed
 - corn gluten meal
- Corn dry mill
 - distiller's grains with solubles
- Cellulose ethanol
 - electricity sold to the grid
- New ethanol plants are assumed to be dry mills or cellulose plants

U.S. Ethanol Production Facilities





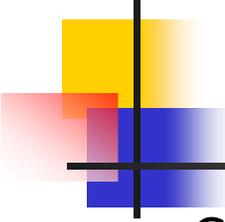
Ethanol Characteristics

- Advantages

- Gasoline substitute
- Improves octane
- Dilutes sulfur and aromatic compounds
- Reduces carbon dioxide emissions
- Every car can use 10% ethanol
- Some newer vehicles can burn E85, with up to 85% ethanol

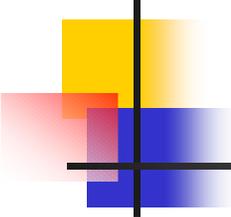
- Disadvantages

- One gallon of ethanol has 2/3 energy of one gallon of gasoline
- Increases gasoline volatility



U.S. Gasoline Formulations

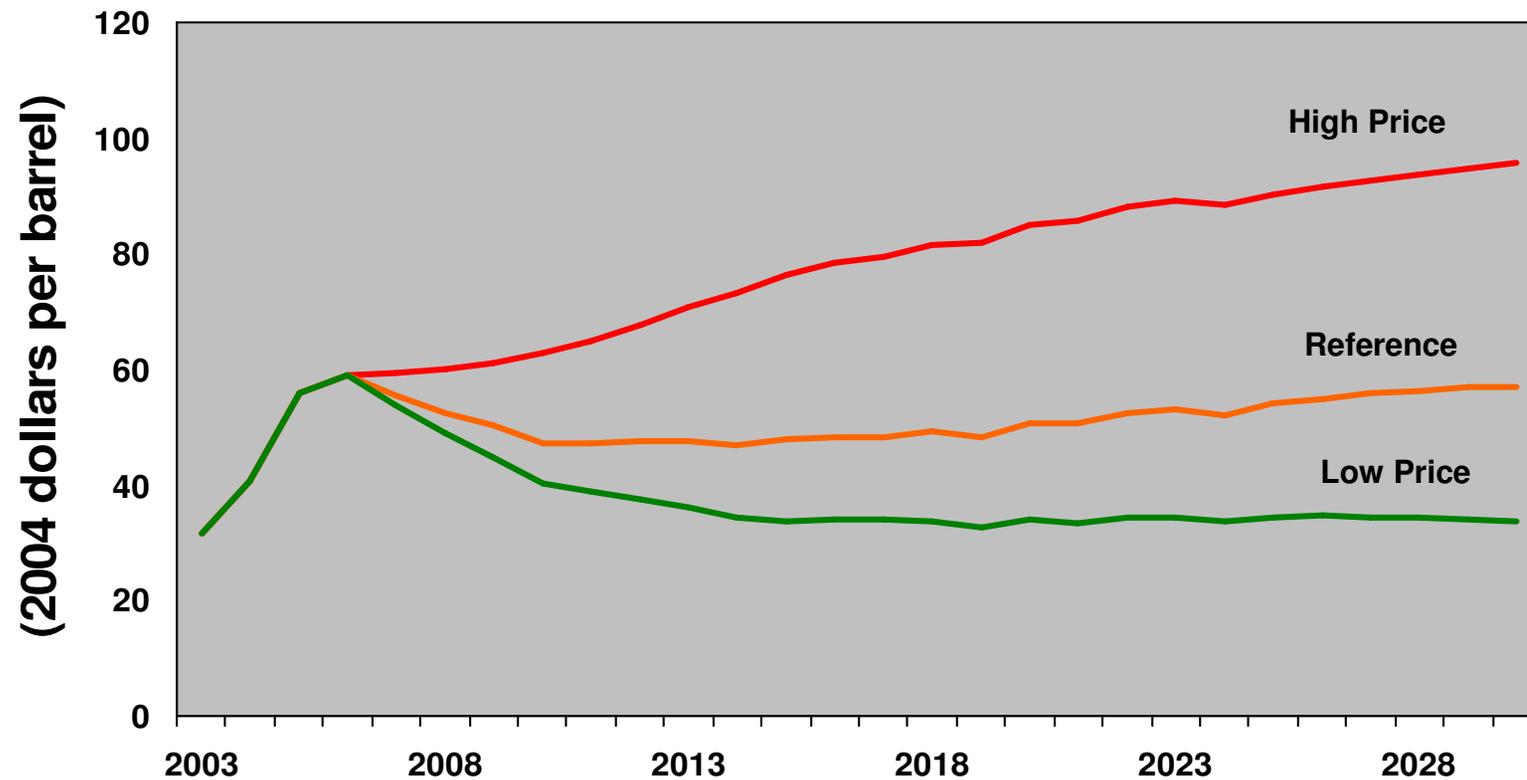
- Conventional
 - Reid Vapor Pressure limit of 9 psi in summer
 - Blending 10% ethanol increases Reid Vapor Pressure to 10 psi
- Oxygenated
 - Conventional gasoline with at least 7.7% ethanol for reduction in winter carbon monoxide emissions
- Federal Reformulated (RFG)
 - Reduced volatility, sulfur, and aromatics content
 - Until this year, ethanol or methyl tertiary butyl ether (MTBE) was required
- California Air Resource Board Reformulated
 - Further reductions in volatility, sulfur, and aromatics



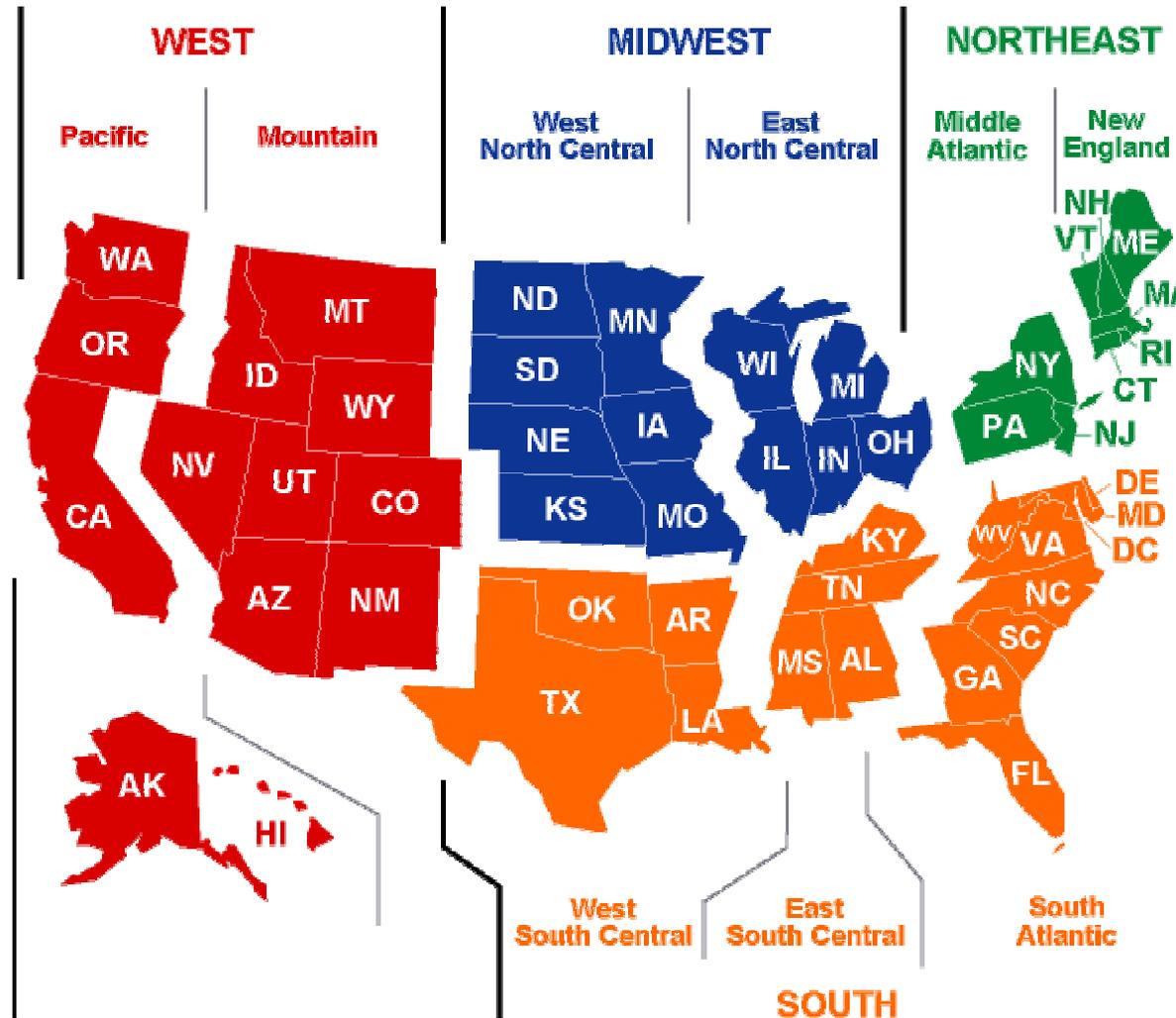
Ethanol Regulations

- Federal excise tax credit of 51 cents per gallon
- Tariff of 54 cents per gallon on imported fuel ethanol
- 1-pound RVP waiver for conventional gasoline
- Corporate Average Fuel Economy benefits for E85-compatible vehicles
- USDA Commodity Credit Corporation grants for expansion of production
- State MTBE bans
- State ethanol requirements
- Minimum renewable motor fuel e.g. ethanol use of 7.5 billion gallons per year in 2012
- Oxygenate no longer required in RFG

Foreign Low-Sulfur Light Crude Price Cases



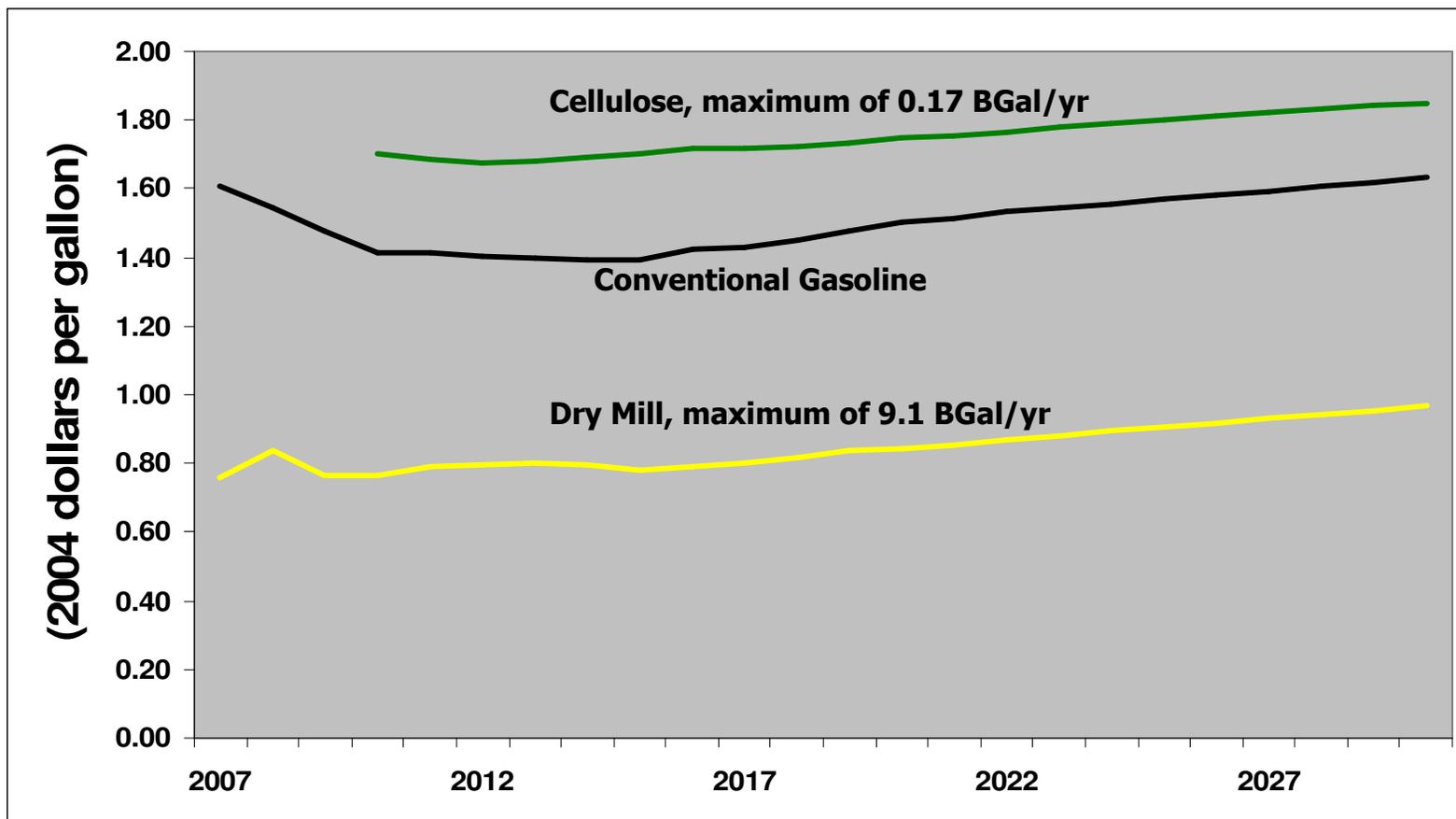
U.S. CENSUS REGIONS AND DIVISIONS



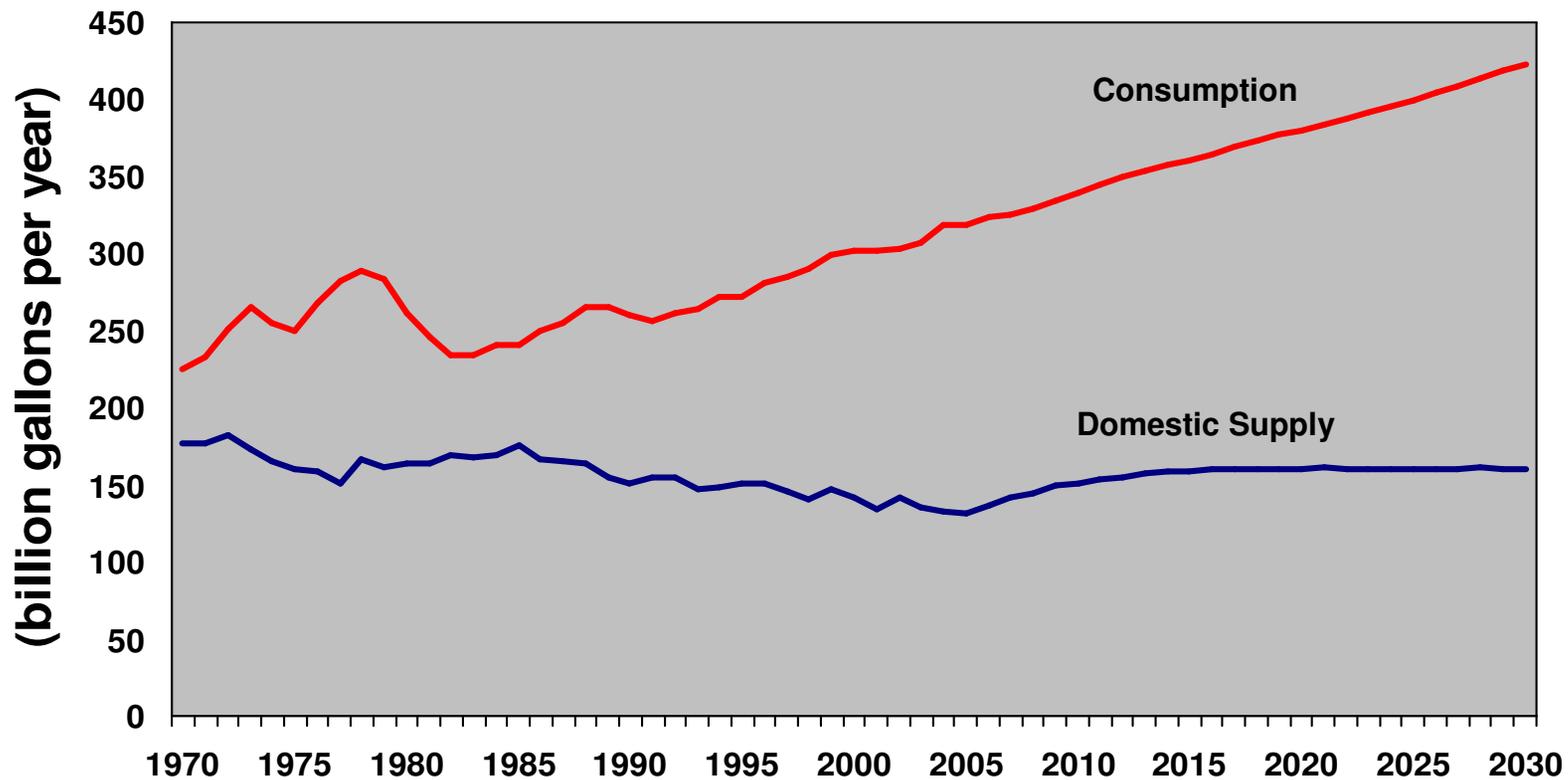
Ethanol Cost by Technology, 2012 (2004 dollars)

	Corn Dry Mill	Cellulose
Raw Material	Corn	Crop Residue, Switchgrass
Coproduct	Distillers' Dried Grains with Solubles	Electricity to Grid
Plant Size	50 million gallons per year	50 million gallons per year
Capital Cost	\$65 million	\$369 million
Raw Material Cost	\$0.90 per gallon	\$0.49 per gallon
Non-energy Operating Cost	\$0.25 per gallon	\$0.63 per gallon
Cost of Delivered Energy	\$0.21 per gallon	\$0
Coproduct Value	-\$0.16 per gallon	-\$0.12 per gallon
Variable Cost	\$1.20 per gallon	\$1.00 per gallon

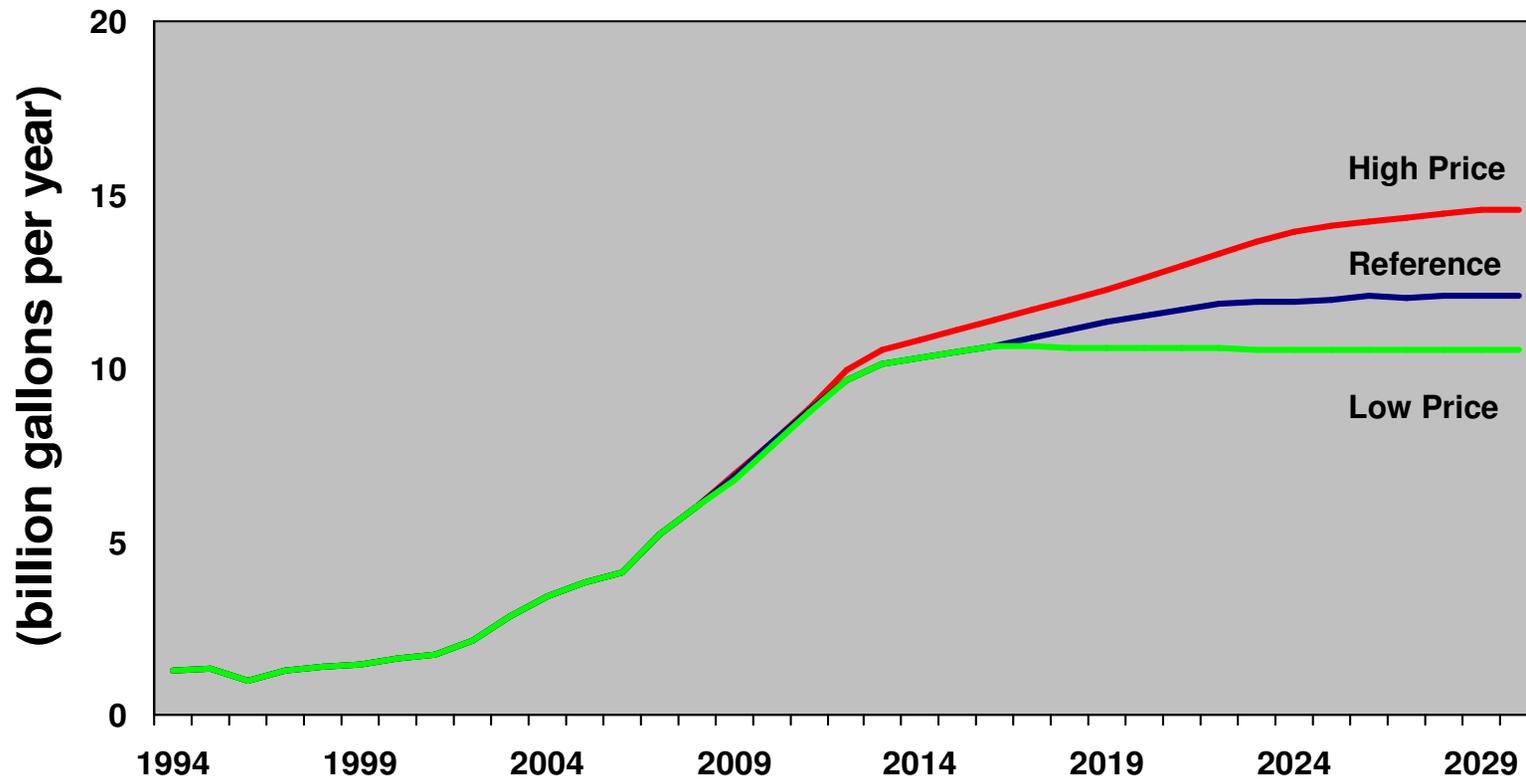
West North Central Division Ethanol Costs Including Tax Credit

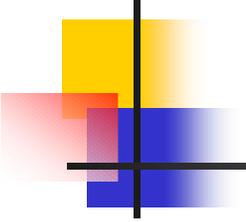


U.S. Petroleum Product Supply and Demand In Reference Case



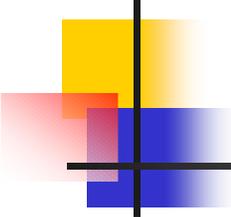
U.S. Ethanol Use By Crude Oil Price Case (billion gallons per year)





Biodiesel

- Methyl ester of soybean oil or yellow grease
- Produced by reaction of vegetable oil with methyl alcohol in the presence of sodium hydroxide
- Glycerine is the byproduct
- Properties vary by raw material
- Permissible level of biodiesel varies by make and model of engine



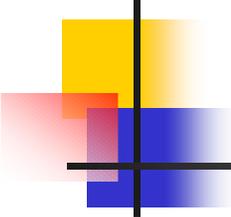
Biodiesel Characteristics

- Advantages

- Diesel substitute
- Less toxic than petroleum diesel
- Reduces particle emissions
- Improves lubricity
- Improves cetane
- Cleans fuel system
- Exhaust smells like French fries

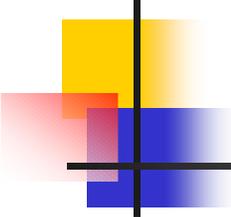
- Disadvantages

- Poorer fuel flow in cold weather
- Increases nitrogen oxide emissions
- Energy content 11% lower than petroleum diesel



Biodiesel Regulations

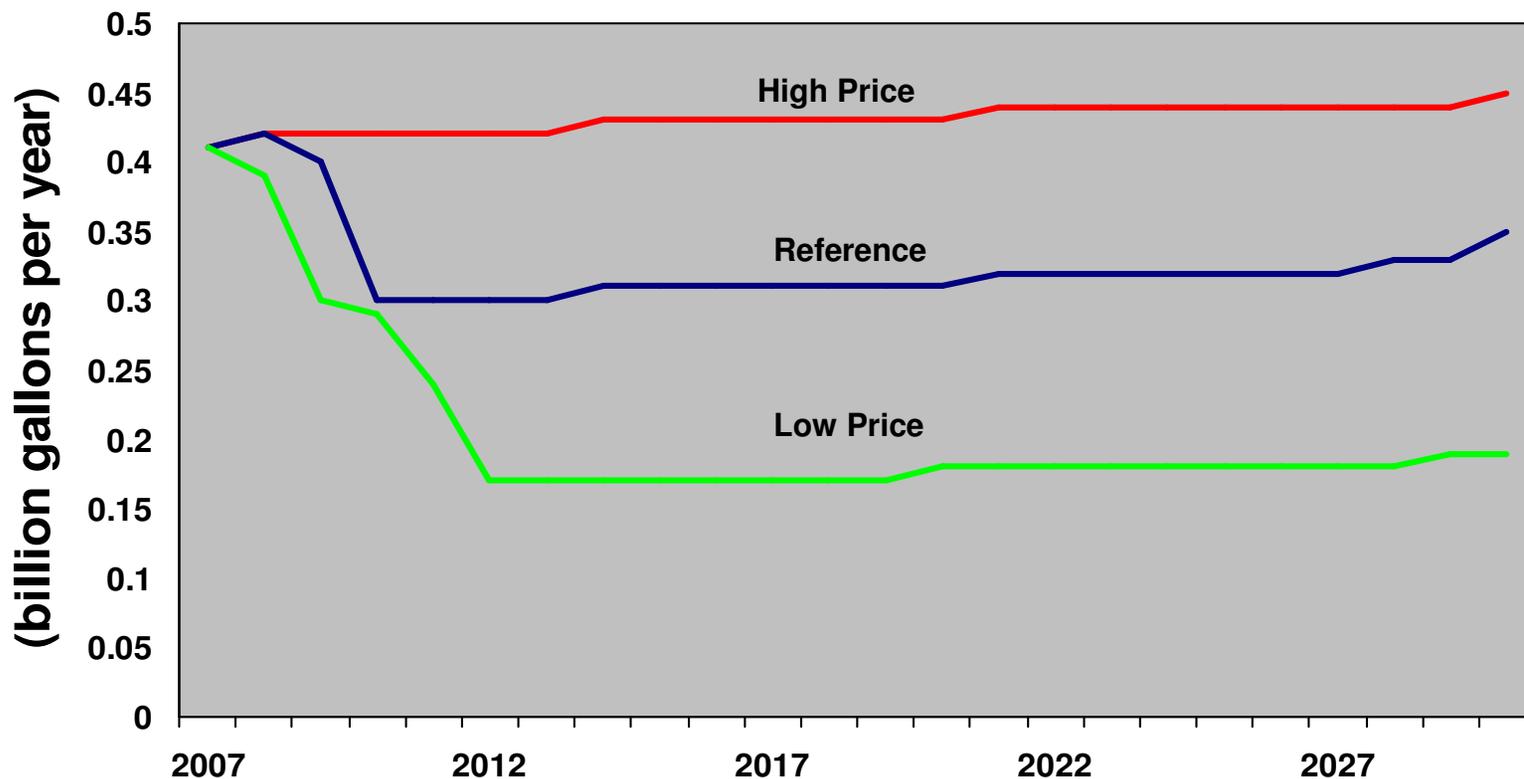
- Federal excise tax credits
 - \$1 per gallon of biodiesel from soybean oil
 - 50 cents per gallon of biodiesel from yellow grease
- USDA Commodity Credit Corporation grants for expansion of production
- Minnesota requires 2 percent biodiesel blends
- Purchase of 450 gallons of biodiesel offsets requirement to purchase one alternative-fueled vehicle under the Energy Policy Act of 1992



Biodiesel Cost by Raw Material, 2012 (2004 dollars)

	Soybean Oil	Yellow Grease
Coproduct	Glycerine	Glycerine
Capital Cost	\$1.30 per annual gallon capacity	\$1.30 per annual gallon capacity
Raw Material Cost	\$2.54	\$1.24
Non-energy Operating Cost	\$0.33 per gallon	\$0.33 per gallon
Cost of Delivered Energy	\$0.14 per gallon	\$0.14 per gallon
Coproduct Value	-\$0.16	-\$0.16
Variable Cost	\$2.85	\$1.55

Biodiesel Use By Crude Oil Price Case (billion gallons per year)



Economic Potentials for Biofuels Production in AEO2006

